Nonrelocatable Occupations at Increased Risk During Pandemics: United States, 2018

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Objectives. To characterize which occupations in the United States could likely work from home during a pandemic such as COVID-19.

Methods. I merged 2018 US Bureau of Labor Statistics (BLS) national employment and wage data with measures ranking the importance of computer use at work and the importance of working with or performing for the public from the BLS O*NET survey.

Results. Approximately 25% (35.6 million) of US workers are employed in occupations (such as technology, administrative, financial, and engineering) that could be done from home; the remaining 75% work in occupations (including health care, manufacturing, retail, and food services) that are challenging to do from home.

Conclusions. Most US workers are employed in occupations that cannot be done at home, putting 108.4 million workers at increased risk for adverse health outcomes related to working during a pandemic. These workers tend to be lower paid. The stress experienced by lower-income groups, coupled with job insecurity, could result in a large burden of mental health disorders in the United States in addition to increased cases of COVID-19 from workplace transmission. (*Am J Public Health.* 2020;110:1126–1132. doi:10.2105/AJPH.2020.305738)

See also Morabia, p. 1111, and the *AJPH* COVID-19 section, pp. 1123–1172.

Initial public health guidance for workers during the 2019–2020 COVID-19 pandemic was focused on ensuring workers stay home when sick, minimize nonessential travel, and practice good hygiene to slow the transmission of SARS-CoV-2 between workers and community members.[1] As the number of cases grew, workers were urged or required to work from home,[2,3] schooling was moved online,[4,5] retail establishments closed or severely reduced hours,[6,7] and food establishments closed or moved to a model of takeout and delivery only.[8,9] These measures, while necessary for halting the spread of a global pandemic, can have drastic effects on workers.

Exposure to infectious disease is often the primary consideration for worker health during a pandemic, particularly for frontline workers such as those in health care. Previously, we calculated the number of workers in occupations in which exposure to infection or disease occurs frequently, using 2018 US Bureau of Labor Statistics occupational employment and O*NET data.[10] We found that about 18% of the workforce is exposed to disease or infection at least once a month at work, putting these workers at an increased risk not only of contracting a disease while at work but also of transmitting an infectious disease into the community.

While exposure to infectious disease is an important occupational health concern during a pandemic, exposure to job insecurity (that is, concern about having a job in the future) is another important metric of worker health to consider. Several researchers have shown a relationship between exposure to acute and chronic job insecurity and measures of adverse physical and mental health outcomes including depression, stress, and physiologic markers such as increased blood pressure.[11–13] Exposure to a job displacement event because of voluntary or involuntary job loss stemming from a layoff, downsizing, or plant closure also has been shown to be related to a variety of adverse mental health outcomes including depression, suicide, and stress[14–16]; negative changes in diet[17,18]; and physical health outcomes such as coronary heart disease and other physiological markers of adverse health.[19,20] After exposure to a job displacement event, workers may take jobs of lower quality, resulting in long-term economic and psychological effects for once-displaced workers.[21] With many workers in the United States receiving health care and other benefits from their work arrangement, a layoff or reduction in hours can affect access to health care or long-term stability for these workers.[22]

Working from home can allow continued productivity when access to a workplace is restricted, such as during the COVID-19 pandemic. However, it is known that not all workers are able to work from home because of differences in job tasks. Jobs that lend themselves to being completed at home are jobs that require limited interaction with the public. Jobs that primarily use a computer to complete tasks also lend themselves to being done at home, given the portability of work on laptop computers.

When access to a workplace is restricted because of a public health emergency, the workers who cannot work from home are likely to experience job disruption, hours reduction, or voluntary or involuntary layoff. During COVID-19, this was exhibited fairly early, with joblessness claims in the United States hitting record highs, especially in

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This article was accepted April 18, 2020.

doi: 10.2105/AJPH.2020.305738

occupations such as food service, retail, hospitality, and manufacturing.[23] Furthermore, workers who are essential personnel and continue going to workplaces (e.g., health care workers, grocery store workers, bus drivers) risk increased exposure to disease and potential increases in job stress attributable to changes in job practices and duties to meet an increase in demand for services. The experiences of workers who cannot work from home will be different between occupations, informed by whether the work is essential, what workplace and regulatory protections exist for the occupation, the pay and benefits they receive, whether they have union protections, and how likely their industry is to return to normal operations after the pandemic event.

Here, I characterized which, and how many, US workers perform job tasks that can be done at home using metrics characterizing the importance of interacting with the public at work and importance of computer use at work and which groups of occupations are likely not able to work from home, putting them at risk for exposure to infectious disease at work and job displacement, disruption, or insecurity during this time. In addition, I investigated how median annual wages differ between occupations that can and likely cannot work from home during a pandemic event to better understand which workers may be most vulnerable to work disruptions during a pandemic event.

METHODS

This analysis utilized measures from 2 existing data sources, as previously detailed in Baker et al.[10] and Doubleday et al.[24] Briefly, I downloaded US employment and median annual wage by occupation, from the US Bureau of Labor Statistics (BLS) Occupational Employment Statistics database.[25] These data were last updated in May 2018 and give a count of the number of US workers employed in each 2010 Standard Occupational Classification (SOC) code and the national median annual wage for each SOC. Guidance around SOC codes is detailed elsewhere[26] but, briefly, SOC codes range from 2 digits (major group code) to 6 digits (detailed occupation code) and are hierarchical in nature. For example, SOC 35-0000 denotes "Food preparation and serving related occupations," with SOC 35-9021 denoting the specific food preparation occupation of "Dishwasher." For this analysis, I utilized 6-digit occupation codes and then aggregated them over larger occupational groupings (i.e., 2-digit codes).

To estimate the number of workers in occupations that could be done at home, I utilized the O*NET database. O*NET is a survey overseen by BLS that asks employees, employers, and job experts across 6-digit SOC codes about exposures encountered at work, knowledge and skills utilized in the occupation, types of tasks performed, and workplace characteristics.[27] O*NET does not collect data from military occupations; thus, SOC codes beginning with 55 "Military specific occupations" are not included in O*NET data. Similarly, employment numbers for "Military specific occupations" are not reported in the BLS Occupational Employment Statistics Database. All other SOC codes are included in the O*NET database, with updates made every year to ensure the database is completely refreshed every few years.[28] Between 2001 and 2017, more than 213 000 employees and job experts representing 180 000 workplaces had responded to the O*NET questionnaire, making it a robust source of occupational information.[29]

I utilized 2 O*NET measures in this analysis. The first characterized the importance of computer use at work via the question, "How important is working with computers to the performance of your current job?" The second O*NET measure utilized was "How important is performing for or working directly with the public to the performance of your current job?" For both questions, respondents could select from the following answers: not important, somewhat important, important, very important, and extremely important. Answers were converted to a 0 to 100 score, representing weighted-average score for each SOC code. A score of 50 is equivalent to a respondent answering "important."

I merged importance scores for both O*NET metrics by 6-digit SOC code with the national employment and annual median wage data. I used annual median wage as opposed to annual mean wage to minimize effects from extreme values. I plotted both O*NET measures against each other, with the resultant scatterplot divided into 4 quadrants. I weighted each SOC on the scatterplot by annual median wage to visualize differences in income among the 4 quadrants.

To further explore relationships in these data, I compared the distribution of median annual wages between quadrants by using a Kruskal–Wallis test.

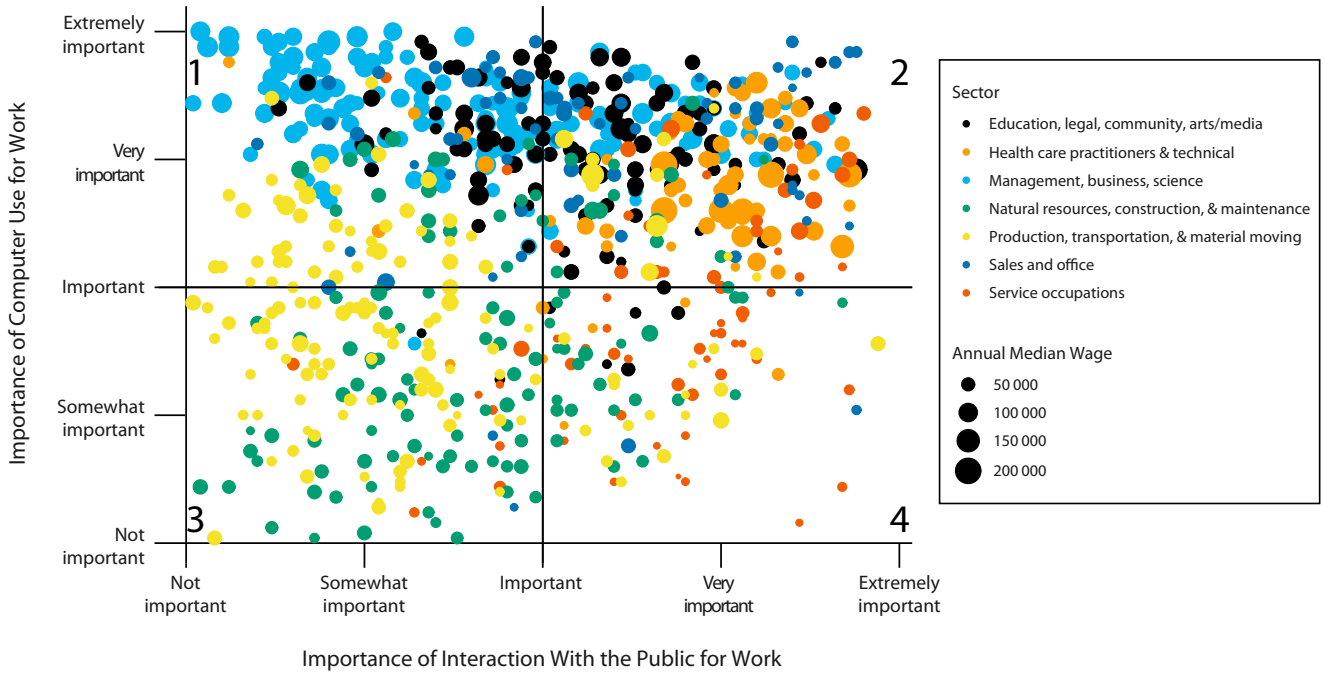
I conducted all data analysis by using the statistical software package R version 3.6.3 (R Foundation, Vienna, Austria).

RESULTS

BLS reported a total of 144.7 million persons employed in the United States in May 2018; this does not include workers in military occupations or those who are self-employed. Figure 1 shows the relationship between "Importance of computer use at work" and "Importance of interaction with or performing for the public at work" for all 6-digit SOC codes. Each SOC plotted here is sized in proportion to the national median annual wage reported for that occupation by BLS, with larger points denoting a higher median annual wage. Each SOC on the plot is color-coded broadly by occupational sector.

Figure 1 is divided into 4 numbered quadrants. SOCs in quadrant 1 represent those occupations that could likely be completed at home—that is, computer use is important to the work, but interaction with the public is not important. As detailed in Table 1, this quadrant represents 24.6% (35.6 million) of the BLS workforce and primarily includes occupational sectors such as business and finance, computer and mathematical, architecture and engineering, and the sciences, as shown in Table 2.

The remaining 3 quadrants in Figure 1 represent occupations that likely cannot be done from home, making them susceptible to not only infectious disease exposure at work but also to job disruption, job insecurity, and potential job displacement if their workplace closes. Quadrant 4 represents occupations in which computer work is not important and interaction with the public is very important. As detailed in Table 1, this quadrant represents 18.9% of the BLS workforce (27.4 million workers) and, as shown on Table 2, consists of occupational sectors such as retail, food service, beauty services (e.g., barbers,



Note. Workers in quadrant 1 are workers who are likely able to work from home, whereas those in quadrants 2, 3, and 4 likely would not be able to work from home. Each point on the graph is weighted by the annual median wage for the occupation and color-coded by broad occupational sector.

FIGURE 1—Relationship Between Importance of Computer Use and Interaction With the Public at Work, Defined by Median Annual Wage and Occupational Sector: United States, May 2018

hairdressers, manicurists), some protective services (e.g., security guards, Transportation Security Administration agents), and transportation operators such as bus drivers or subway operators.

Quadrant 2 represents occupations in which both interaction with the public and computer use are important and accounts for 36.4% (52.7 million) of the BLS workforce. These workers primarily are in management, health care, legal, and elementary and secondary education. Quadrant 3 represents occupations in which both interaction with the public and computer use are not important, accounting for 20.1% (29.0 million) of the BLS workforce. These are typically workers in construction, maintenance, production, and natural resources.

TABLE 1—Distribution of US Median Annual Wages Across 4 Groups Defined by Importance of Computer Use and Interaction With the Public at Work (Quadrant): United States, May 2018

	Average Median Annual Wage, $				
Quadrant	Mean	Median (IQR)	Workers, % (No.)	95% CI[a]	*P*[b]
1. High computer, low public	66 196	62 710 (44 380–83 555)	24.6 (35 583 140)	. . .	. . .
2. High computer, high public	62 596	56 950 (39 818–74 128)	36.4 (52 744 670)	970, 9 820	.017
3. Low computer, low public	40 068	38 190 (30 170–47 170)	20.1 (29 032 800)	18 150, 27 250	< .001
4. Low computer, high public	34 258	32 040 (24 580–40 060)	18.9 (27 370 610)	23 140, 33 710	< .001
All	55 489	48 650 (35 595–68 215)	100 (144 731 220)	. . .	< .001[c]

Notes. CI = confidence interval; IQR = interquartile range.

[a]95% CI of difference in median wage compared with quadrant 1.

[b]Wilcoxon rank-sum test of median annual wages compared with quadrant 1.

[c]Kruskal–Wallis analysis of variance test of median annual wages compared between all 4 quadrants (95% CI is not informative for this measure).

Table 1 summarizes the distribution of median annual wages across each quadrant. A Kruskal–Wallis 1-way analysis of variance test indicated that the median annual wages between these quadrants were significantly different. The quadrant with the highest annual median wage was quadrant 1, workers who could likely work from home, with a median annual wage of $62 710. The lowest annual median wage was in quadrant 4, which was $32 040. This $30 670 difference (95% confidence interval = $23 140, $33 710) is statistically significant when applying a Wilcoxon rank-sum test ($P < .001$).

Table 2 details total employment and median annual wage by 2-digit SOC and the percentage of workers in each 2-digit SOC code that falls into each of the 4 quadrants.

DISCUSSION

During the COVID-19 pandemic, US workers were urged or required to work from home to help halt disease transmission. However, only about a quarter of US workers are in occupations that can be done at home, with

TABLE 2—Employment and Annual Average Median Wage by 2-Digit Standard Occupational Classification Code and Percentage of Total Standard Occupational Classification Codes Distributed Across 4 Groups Defined by Importance of Computer Use and Interaction With the Public at Work (Quadrants): United States, May 2018

2-Digit SOC	Median Annual Wage, $	Total in SOC	% SOC Distributed in Each Quadrant			
			1	2	3	4
11: Management	104 240	7 616 650	32.0	68.0	. . .	. . .
13: Business and financial operations	68 350	7 721 300	72.7	27.3	< 0.1	. . .
15: Computer and mathematical	86 340	4 384 300	100.0	. . .	. . .	. . .
17: Architecture and engineering	80 170	2 556 220	90.8	9.2	. . .	. . .
19: Life, physical, and social science	66 070	1 171 910	63.6	36.3	. . .	. . .
21: Community and social services	44 960	2 171 820	. . .	97.8	. . .	2.2
23: Legal	80 810	1 127 900	9.9	90.1	. . .	. . .
25: Education, training, and library	49 700	8 779 780	26.7	50.6	20.0	2.8
27: Arts, design, entertainment, sports, and media	49 290	1 951 170	43.7	47.0	. . .	9.3
29: Health care practitioners and technical	66 440	8 646 730	7.7	90.5	. . .	1.9
31: Health care support	29 740	4 117 450	1.3	38.7	36.6	23.3
33: Protective service	40 640	3 437 410	4.4	54.8	. . .	40.8
35: Food preparation and serving related	23 070	13 374 620	. . .	8.2	10.4	81.4
37: Building and grounds cleaning and maintenance	26 840	4 421 980	. . .	2.3	70.4	27.3
39: Personal care and service	24 420	5 451 330	. . .	22.6	40.8	36.6
41: Sales and related	28 180	14 542 290	12.5	61.9	0.0	25.6
43: Office and administrative support	35 760	21 828 990	45.6	52.0	0.8	1.6
45: Farming, fishing, and forestry	25 380	480 130	. . .	5.0	86.7	7.9
47: Construction and extraction	46 010	5 962 640	. . .	2.2	76.0	21.9
49: Installation, maintenance, and repair	45 540	5 628 880	30.7	23.3	38.9	7.0
51: Production	35 070	9 115 530	21.1	1.7	74.2	3.0
53: Transportation and material moving	32 730	10 244 260	4.8	5.9	48.4	41.1
All SOCs	38 640	144 733 290	24.6	36.4	20.1	18.9

Note. SOC = Standard Occupational Classification code. Quadrant 1 is defined as high computer use, low public interaction. Quadrant 2 is defined as high computer use, high public interaction. Quadrant 3 is defined as low computer use, low public interaction. Quadrant 4 is defined as low computer use, high public interaction.

about 75% of the US workforce (represented in quadrants 2 to 4 on Figure 1) either remaining in the workplace and risking increased exposure to infectious disease or experiencing job insecurity, disruption, and displacement because of workplace closure. The occupations that can be done at home have, on average, higher median wages than occupations that cannot be done at home, further increasing the differences in vulnerabilities between these 2 groups.

Differences in exposure and experiences for these 3 quadrants that cannot work from home must be noted. Those workers in quadrant 2 are workers in jobs in which interaction with both the public and computers are important. Many of these workers are in essential services, such as health care and education, making them less likely to be displaced from work. Those who are able to transition to working from home will likely experience work disruptions attributable to working in a new modality, such as teaching elementary students online

or transitioning to telemedicine. The workers who continue to go to work will face increased exposure to disease, in addition to other workplace disruptions such as potentially being asked to work different hours or perform different tasks. Like the workers in quadrant 1, these workers tend to have wages above the national median and likely increased access to benefits and job protections through union and workplace protections.

Those in quadrant 3 are largely in construction, maintenance, natural resources, and manufacturing. Many of these workers are in jobs that may not be considered to be essential services[30] making them susceptible to job displacement or hours reductions if a shelter in place is ordered. If workplaces are open, workers may work in close proximity to other workers on jobsites, increasing risk of exposure to infectious disease. Despite lower-than-median wages, many of these workers may have some protections from their union in addition to other regulatory protections and increased certainty of a return to work when public health orders are lifted, given the vital nature of their work.

The workers in quadrant 4 are those workers for whom using a computer is not important, but interacting with the public is. These workers, largely in food services, some protective services, personal care, and transportation, could face job displacement and job insecurity as nonessential businesses are asked to close for public health reasons and the public avoids nonessential activities. Those working in grocery stores and other essential retail are less likely to face job displacement during a public health emergency as their workplaces will remain open. However, if schools close, essential workers that cannot work from home may have to choose between quitting their job or reducing their hours to stay home with children or going into work without adequate back-up care for their children, further contributing to a feeling of insecure employment and stress. Importantly, these workers are also at increased risk of exposure to SARS-CoV-2 and may have to choose between continuing to work and risking exposure or quitting with no safety net, which could be a particularly challenging decision for a worker in a high-risk group (e.g., older, pregnant, immunocompromised).

Other data sources have quantified the number of US workers that work from home, including the American Time Use Survey, US Census American Community Study, and the National Compensation Survey. However, these data sources do not quantify how many and which types of workers have work that feasibly can be done at home when workers are ordered to do so. The National Compensation Survey characterizes how many workers have access to a remote working benefit as part of a compensation package, regardless of whether a respondent took advantage of it,[31] and the American Time Use Survey and the American Community Study characterize whether a worker worked from home on the day the survey was administered, regardless of whether it was paid work or not.[32,33] The work presented here quantified the number and types of workers who could work from home if it was ordered in an emergency, which is an important distinction from the previously mentioned data sources.

The COVID-19 pandemic and other public health emergencies and disasters tend to exacerbate existing disparities in society, which was also shown in this analysis. Here, I showed that the distribution of median annual wages differed between those workers who would likely be able to work from home and those workers who would likely not be able to work from home, further adding to the vulnerability of lower-income workers during the COVID-19 pandemic. Workers who are able to work from home will have some continuity in pay, increased ability to care for a child out of school, decreased risk of being laid off or having hours substantially cut, and decreased potential exposure to disease or infection via other workers or community members. This further exemplifies the importance of work as a social determinant of health and highlights the importance of understanding which workers are in more vulnerable jobs during an emergency or disaster and the risks and challenges these groups face.[34]

Limitations

Limitations related to the data used here must be acknowledged. BLS data do not count self-employed (which includes a variety of workers ranging from gig economy workers to highly trained independent consultants, for example), undocumented, contingent, military, and domestic workers. This undercoverage of the working population in the BLS survey could affect conclusions presented here.

O*NET relies on employee and employer self-report, so is subject to inherent bias and misclassification during collection. Furthermore, data collected by O*NET are aggregated on the occupational level, and I further aggregated data into quadrants, meaning that within-occupation and within-quadrant variation is not accounted for in this analysis.[35] This will lead to misclassification both within the occupations and within each quadrant. The O*NET metrics used in this analysis were measures of the importance of using a computer for work and importance of interacting with the public, which differs from the frequency of using a computer or frequency of interacting with the public. Therefore, some jobs for which computer use is rated as very important may not actually require use of a computer very frequently, and jobs in which interaction with the public is rated as important may not actually interact with the public frequently. In addition, there are computers that are used in work settings that would not necessarily be able to be used at home, such as computers that are specific to a manufacturing or medical process. These considerations lead to further misclassification in the analysis for who could work from home most easily.

Public Health Implications

Understanding the unique challenges that workers who cannot work from home could face during a pandemic or other public health emergency can help to inform appropriate risk management and policy-based strategies for these workers to ensure that their livelihood can continue. This work shows that only about 25% of the US workforce are in jobs that could continue to be done at home during a pandemic event. These workers would be protected from disease exposure because of working from home and typically have higher-paid jobs with more workplace

protections, further protecting these workers from adverse health effects related to job insecurity, job stress, and job displacement.

The rest of the workforce (about 75% across quadrants 2 to 4 in Figure 1) are in occupations that would face increased exposure to disease and infection if they are still working out of their workplaces and increased exposure to psychosocial factors such as job displacement, disruption, and insecurity if they are not able to work out of their workplaces. These workers could also face stress and job insecurity as they may have to choose between going to work and being exposed and staying home to protect themselves or care for a family member.

Experiences and outcomes for these workers during a pandemic event would likely be modified by workplace characteristics, such as available workplace controls, workplace policies and benefits, whether workers are unionized, whether workers qualify for state or federal unemployment protections, worker pay, and the probability of returning to work once normal operations resume.

In this analysis, I found that the workers with the lowest average median wage are workers who are not able to work from home and include those in occupational groups such as food services, retail, personal care, and some transportation workers. Workers in this quadrant have an average annual median wage about $30 000 less than the workers who can work from home, and these workers often lack protections such as employer-provided health care, appropriate sick leave, or paid time off, further increasing their vulnerability during a public health emergency and enforcing the role of work as a social determinant of health.

While all workers will be disrupted during a pandemic event such as COVID-19, increased public health focus should be on those who are the most vulnerable, including ensuring these workers are adequately protected at work and have social protections in the event they are no longer able to work. This will ensure that these workers do not bear an undue health burden during a public health emergency and will also help to reduce the burden of adverse health outcomes that could emerge in these workers who cannot work from home during a pandemic event. AJPH

ACKNOWLEDGMENTS

Research reported here was supported by the National Institute for Occupational Safety and Health (NIOSH) under Federal Training Grant T42OH008433.

The author gratefully acknowledges Annie Doubleday for developing the R code that supported this analysis.

Note. The content is solely the responsibility of the author and does not necessarily represent the official views of NIOSH.

CONFLICTS OF INTEREST

The author has no conflicts of interest to declare.

HUMAN PARTICIPANT PROTECTION

Research presented here is not human participant research, so institutional review board approval was not needed.

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